## Overview

Biomass is a general term for all of the Earth's plant and animal matter. In the renewable energy industry, however, biomass usually refers to: (1) energy crops grown specifically to be used as fuel, such as fast-growing trees; (2) agricultural residues and by-products, such as straw, sugarcane fiber, and rice hulls; and (3) residues from forestry, construction, and other wood-processing industries. (*Note: As defined here, biomass does not include municipal solid waste or landfill gas.*)

Biomass currently accounts for around 1% of total U.S. electric generating capacity, or 8% of the country's renewable-source generating capacity. In 1995, there was approximately 7700 MW of grid-connected biomass power capacity in the United States.

According to a 1992 study by Meridian Corporation and Antares Group Inc., the biomass power generation industry employs more than 66,000 people nationwide. In 1992, the industry created more than $1.8 billion in personal and corporate income, and generated more than $460 million in federal and state taxes.

Because biomass power activities tend to be concentrated in rural areas, this technology offers a great opportunity for revitalizing rural America. The U.S. Department of Energy (DOE) estimates that a concerted effort to develop dedicated energy crops for biomass power plants could generate 120,000 new jobs over the next 15 years.

## Success Stories

### Maine: Leading the Nation

Maine obtains a greater percentage of its electricity from nonhydro renewable sources than any other state. The biomass power industry generates 25% of Maine's electricity and supports 2780 jobs in wood harvesting and transport, power plant construction and operation, and associated retail and service sectors. The industry has nearly 500 MW of installed capacity in 21 generating plants.

Northern States Power/PIX00240

***The biomass power industry creates thousands of jobs in fuel production and harvesting for rural workers, such as this grapple operator on a tree farm in Oregon.***

*"Small power producers ... have been one of Maine's largest sources of new employment and investment."*

**— State Planning Office of Maine, quoted in *Energy Choices Revisited: An Examination of the Costs and Benefits of Maine's Energy Policy*, Mainewatch Institute, 1994**

In rural districts with limited employment opportunities, a single power plant can have a critical impact on the local economy. This is the case with Fairfield Energy Venture, a 32-MW biomass plant located in the town of Fort Fairfield in northeastern Maine.

### Everyone's a Winner

The Fairfield Energy facility provides approximately 140 jobs (38 at the plant and about 100 in wood harvesting) and more than 30% of the town's property tax base. With a population of 4000, and only about 1270 jobs available in the area, the biomass plant is vital to the health of the town's economy. "We consider ourselves lucky to have the energy plant," acknowledged a representative of the Fort Fairfield Chamber of Commerce.

The biomass plant has generated substantial economic benefits for the local and state economies, both during initial construction and since. The facility was completed in 1988 after a two-year construction period. During this phase, the plant's developers spent more than $8 million in the state of Maine, including $5.3 million paid in wages to local workers for on-site assembly and construction.

In 1992, Fairfield Energy Venture had annual operating expenses of $12 million, $9.4 million of which was spent in the state's economy. Of the in-state expenditures, more than $7 million stayed in Fort Fairfield and the surrounding area. This includes $1.7 million in wages and salaries paid to plant employees and more than $938,000 paid to the local and state governments in property taxes, fees, and licenses.

A 1994 Mainewatch Institute study found that, "From the start of the project it appears the town and local area have been winners. Local tradespeople were employed in the on-site construction; parts and supplies were purchased from local outlets whenever possible; and the influx of engineers, consultants, and temporary out-of-town workers provided substantial benefits to local restaurants, gas stations, motels, and food stores."

Fairfield Energy Ventures is also expanding the skill base of local workers. Only one of the plant's employees had any previous experience working in a power plant. The Mainewatch Institute study quotes Peter Powers, the plant's general manager, as saying, "All but one of our employees were Maine residents prior to being hired by the plant and all live in close proximity to the plant." Seven of the employees (including the general manager) had previously worked in the navy, and were able to make use of their training in steam propulsion. Many of the plant workers were hired at entry-level positions, and the company is committed to training them to help ensure job advancement and employment stability.

## How It Works

Because plants and trees use sunlight to grow, biomass energy is actually a form of stored solar energy. Biomass energy can be converted to electricity in two ways:

*Direct combustion* involves burning the biomass in a boiler to heat water, then running the resulting steam through a turbine — the same process used in conventional coal-fired plants. Virtually all biomass electric plants today use conventional steam turbines.

*Gasification* involves converting the solid biomass to a gas that is then burned in a combustion turbine — potentially much more efficient, but still in the demonstration stage of development.


Warren Gretz, NREL/PIX03744

*Harvesting alfalfa in Minnesota. Damaged crops can still be used as a biomass feedstock.*

## Income from Energy Crops

To expand power production from biomass substantially beyond current levels will require the cultivation of dedicated energy crops. New York has become the focus for a new initiative to develop agricultural feedstocks for energy production. This should help to stabilize the revenue stream for participating farmers: 26 area farmers have expressed a desire to diversify their crop production to include energy feedstocks.

Warren Gretz, NREL/PIX00308

***Most agricultural wastes can be used to generate electricity, including the mountains of fibrous material left over from processing sugarcane crops such as this one in Hawaii. Selling power to electric utilities helps to improve the economics of sugar production for local companies.***

The Niagara Mohawk Power Corporation and the State University of New York (SUNY) are members of a consortium that is developing willow energy crops on 1000 acres of farmland around Tully, New York. This is the first stage of a plan to convert over 40,000 acres in central and western New York to growing willow trees for energy by 2010. Once it is fully implemented, the plan is expected to create 300 rural jobs and generate energy crop fuel sales of almost $20 million annually.

Each New Yorker sends an average of $1000 each year out of state to purchase energy. In 1992, only one half of New York's farmers were able to earn a profit on farm operations. A "homegrown" willow crop bought by power companies will help keep energy dollars in the state and generate new income streams for farmers.

According to Dan Robison, a researcher at SUNY's Syracuse College of Forestry, "There are a lot of farmers in New York who are struggling to stay in business. There are a lot of farmers throughout the region who are essentially working for free, on a break-even basis, and any new opportunities — they're interested."

Hybrid willow species are being developed by the project partners to be fast-growing and resistant to drought and disease. Male willow trees can thrive in soils and climates less suitable for other crops. These trees require minimal application of fertilizer and insecticides and will assist in the control of soil erosion. Because willow is planted once, then repeatedly harvested from the same plant for up to 20 years, soil erosion is minimized compared to traditional row crops.

"This is ... a very good alternative farm crop ... a cash crop," said Larry Abrahamson, another of SUNY's researchers.

## Bad Weather? Good News …

The agricultural community of Granite Falls, Minnesota, will soon become the home for a new 75-MW biomass gasification power plant that will be built just outside of town. The plant will employ 100 full-time staff and will create an additional 60-80 part-time jobs for people handling the biomass feedstock.

*"It's going to generate jobs in the community — the plant itself — but the other part of it is that it's economic development with the farmers."*

**— Farmer Dick Jepson, in an interview for the 1996 DOE video, *Growing America's Energy: The Story of Biomass Power***

A small group of area farmers and business people are developing alfalfa as an energy crop for the power plant. Alfalfa is normally grown primarily for use as cattle feed. When bad weather destroys the crop, it can no longer be fed to cattle, but the damaged stems can still be used as a feedstock for electricity production.

"We'll have a ready market for the stems," said John Moon, a local farmer. "A brown stem has just as much quality for gasification as a nice stem that hasn't been rained on."

In good years, the alfalfa crop will be separated into stems and leaves. The leaves will be sold as cattle feed, and the stems will be sold to the biomass plant. So in addition to producing clean energy for Minnesotans, the plant provides a second source of income for area farmers.

Because biomass plants can use a wide range of organic material, the technology is suitable for generating power in virtually any agricultural region — as far east as Maine, or as far west as Hawaii.

## Electricity from Sugarcane

For a state such as Hawaii, which is currently forced to generate most of its electricity from expensive, imported fuel oil, renewable energy resources are particularly valuable. Approximately 8% of Hawaii's electrical power is already being generated from biomass, the state's largest source of renewable energy, and research is under way to make better use of this resource.

Most of Hawaii's biomass plants use bagasse, the fibrous waste from sugarcane processing. Sugar is Hawaii's most important agricultural export, and local sugar mills burn bagasse to provide thermal power to the mills and electricity for sale to utility grids. These mills use direct-fired steam-turbine generators. Because biomass gasifiers are more efficient, they are potentially capable of producing 50% more electricity from the same amount of bagasse when compared with systems that burn the bagasse directly. This has prompted the State of Hawaii to explore gasification technology in partnership with DOE and an industry research group.

The government-industry joint venture has built an experimental gasification facility at the Hawaiian Commercial & Sugar Company mill in Paia, on the island of Maui. The facility currently processes almost 100 tons of bagasse per day into biogas. Jerry Smith, the manager of the project, knows how important electricity produced from biomass is to Hawaiians.

*"It keeps the people on the island working. Plus, with a plant this size, you're not dependent on importing oil. And that's a big thing when you're sitting on an island."*

**— Jerry Smith, Paia gasifier project manager, in a 1996 interview for *Growing America's Energy: The Story of Biomass Power***

Warren Gretz, NREL/PIX03810

***Compared to conventional steam turbines, biomass gasifiers are capable of getting 50% more electricity from the same energy crop. Hawaii's first gasification facility, at Paia on the island of Maui, is pictured receiving a traditional blessing on dedication day.***

The experiment shows how the sugar mills can generate more electricity with the same resources and make more money from selling power to the utility; this benefits the local sugar industry by helping to keep Hawaiian sugar competitive in worldwide markets.